SPACE SYSTEMS SYMPOSIUM (D1)
Space Systems Architectures (4)

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METHODOLOGY OF HIERARCHICAL CONTROL OPTIMIZATION FOR SPACECRAFT ORBIT GROUPS

Abstract

In the context of anticipated large-scale development of spacecraft orbit groups there is a number of additional factors and the rising number of system elements which influence spacecraft control process. Besides it is difficult to take into consideration the exact influence of all interconnected factors as they are either of random character or described by complicated mathematical models. Analyzing the functioning of all the complex of system elements we can single out the main hierarchical levels of spacecraft groups' control. It makes necessary to develop new methodological approaches for hierarchical optimization of control processes. In this work there is a new methodology of hierarchical control optimization of spacecraft orbit groups based on the use of mathematical tools of Markov's continuous processes theory. It is supposed that the system evolution is described as controlled unsteady Poisson flows of events consisting in coherent transition of the system from one state to another. At that the transitions can be completed between the states referring to one hierarchical level and to different levels as well. The state graphs of system state are composed taking into consideration the revealed hierarchy levels. The transition intensities are determined between the adjacent states. The differential equations of Fokker-Planck-Kolmogorov are developed for the calculation of probabilities for finding the system in each possible state. It allows determining statistical characteristics of the system and modelling of its time history. The formalism of maximum principle was used for the developed differential equations which gives an opportunity to determine optimal control of system functioning processes. As an optimality criterion the minimum of time for system transfer from the initial state to the final one was used. The proposed methodology makes possible to solve optimal control tasks of future spacecraft orbit groups that is to determine the rational schemes for the use of control means and develop optimal control actions for the system on the whole. At the same time not only the application efficiency of alternative variants of

system construction can be evaluated but also the critical units of the system are determined for each variant under consideration. Application of the developed methodology for control practice will allow to considerably raise the efficiency and performance of object functions by spacecraft orbit groups and extend their on-orbit life.